Journal of the Saudi Society of Agricultural Sciences (2016) xxx, xxx–xxx

King Saud University

Journal of the Saudi Society of Agricultural Sciences

www.ksu.edu.sa
www.sciencedirect.com

FULL LENGTH ARTICLE

Comparing economic efficiency of wheat productivity in different cropping systems of Sindh Province, Pakistan

Mansoor Ahmed Koondhar [a], Lingling Qiu [b], Habibullah Magsi [c], Abbas Ali Chandio [b], Ge He [a,*]

[a] *College of Management, Sichuan Agricultural University, Chengdu 611130, China*
[b] *College of Economy, Sichuan Agricultural University, Chengdu 611130, China*
[c] *Department of Agricultural Economics, Sindh Agriculture University, Tandojam, Pakistan*

Received 14 July 2016; revised 17 September 2016; accepted 18 September 2016

KEYWORDS

Wheat farming;
Economic analysis;
Sustainable farming;
Production function;
Sindh Pakistan

Abstract The data for this empirical study were collected from three major cropping systems of Sindh province, and a total of 240 farmers were selected by simple random sampling technique. Cobb-Douglas production function was applied to analyze the data. Results show that in mixed cropping zone wheat yield increased with increasing ploughing, seed and plant protection. The dominant factors behind yield increase in the cotton-wheat cropping zone were ploughing, seed, fertilizer, and irrigation. Wheat yield in the Rice-wheat zone increased linearly with increasing ploughing, seed and fertilizer as well as plant protection measures. Further the results show that salinity and water logging are the driving threats leading to high water table in most regions of upper Sindh. Due to poor land management and improper irrigation strategies, the coefficient of irrigation shows negative value. Contrarily, lower Sindh needs canal irrigation water (i.e. Mixed and cotton-wheat zone), because most of the areas have unfit ground water for irrigation, thus increasing the soil erosion and salinity in lower Sindh. Furthermore, the cost of production estimated in cotton-wheat zone's grower spends more USD$841/ha as compared to rice-wheat zone's grower and Mixed cropping zone's grower spend USD$827/ha and USD$780/ha. The growers of the whole Sindh spend USD$816/ha. In case of gross income cotton-wheat zone's grower received higher than 1287, followed by the growers of mixed cropping zone and rice-wheat zone received USD$1248/ha and USD$1132/ha due to high cost of production. The overall Sindh growers received USD$1222/ha. In the case of net return grower of mixed cropping zones received higher USD$481/ha, compared to cotton-wheat zone's and rice-wheat zone's grower received USD$451/ha and USD$308/ha,

* Corresponding author.
E-mail address: 3115059778@qq.com (G. He).

Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.jssas.2016.09.006

Please cite this article in press as: Koondhar, M.A. et al., Comparing economic efficiency of wheat productivity in different cropping systems of Sindh Province, Pakistan. Journal of the Saudi Society of Agricultural Sciences (2016), http://dx.doi.org/10.1016/j.jssas.2016.09.006

respectively. The growers of the whole Sindh province received USD$413/ha net return from wheat crop. The production of wheat is lower as compared to cost. Therefore, net income of per acre and the production cost of per acre reduce with farm size, so increasing the use of inputs should assure the quantity and quality by the approach of growers.

1. Introduction

Agriculture performs a vigorous role in the economy of Pakistan. Agriculture provides raw material for agro-based industries. The most significant role of agriculture in the economy of Pakistan was to generate surpluses for export to earn foreign exchange which is much needed. It accounts for 21.9% shares in the Gross domestic product (GDP) (GoP, 2015). Almost 70% of people live in rural areas and engage unswervingly or circuitously in agriculture for the livelihood (GoP, 2003). Wheat is the leading grain food of Pakistan and provides stable diet for people. What's more, it occupies a dominant position in the formulation of agronomic strategies. It is grown in about 39.12% of the cropping area and accounts for 73.66% of the total grain food production. Wheat contributes about 10.3% to the value added in economy agriculture sector and 2.2% in GDP (Usman, 2016). The performance of wheat crop affects the overall growth rate, import bill of economy and nutritional standard of urban poor people. In Sindh, wheat was grown in an area of about 1.106 million hectares (9.59% of the national acreage), with a production of about 1.204 million tonnes (14% of national production), during the year 2014–2015 (GOP, 2015–16). The average yield of Sindh, in that year, was around 3747 kg per hectare or about 32.26% higher than the national average yield. Although the yield has increased year after year by introducing high yielding varieties, it is still very low compared with advanced wheat-producing countries of the world. The low crop production due to decrease in Area, heavy rainfall flood, climate changes the main effect of reducing production due to government of Pakistan announced unwanted policies about supporting price (Koondhar et al., 2016). To meet the domestic needs of the growing population, the country imported million tons of wheat in the past few years. Pakistan has the least yield record of wheat per acre in the world, of 23 mnd per acre, whereas Netherlands has a capacity of 91 mnds, Denmark 78 mds, England 77 mds, New Zealand 74 mds, Germany 65 mds, France 62 mds, Egypt 61 mds, Japan 40 mds, USA 30 mds and India 26 mds per acre yield (Cinteol and Azetec Maize Diety, 2015).

Even though tremendous efforts have been made by the wheat breeders in developing new high-yielding varieties during the past three decades, wheat production in Pakistan remained short of demand and thus import has been the only alternative to fill the gap. The present wheat requirement of the country is more than 20 million tons. It has been estimated that by the year 2020 wheat import would have risen up to 15 million tons costing 2 billion US dollars (PARC, 1996). The situation could worsen further if Pakistan fails to achieve a higher level of growth rate in wheat production. Under the present wheat production system and productivity scenario, the realization of this objective appears to be highly unlikely (Byerlee and Siddiq, 1994; Rajarams et al., 1998). Wheat production in the country, however, has been well below a potential variable. The main goal of this study was to estimate production cost physically, revenue productivity and net return to realize by wheat growers in different cropping zones of Sindh province and to analyze which factors in what cropping systems effect on wheat production and to suggest policy recommendation for enhancing wheat production.

2. Research methodology

The survey methodology has been commonly used to collect cross-sectional primary data from the target population. A wide range of problems and situations can be investigated by using this approach (Gall et al., 1996). Survey methodology provides the plan for the study and overall framework for collecting data. This is an effective way to measure responses on fairly easy fashion as it uses well developed questionnaire. The methodology includes data source, study area, sampling procedure, data collection and data analysis procedure. Finally, it ends up with the comparative economic analysis of wheat yield of different cropping areas of Sindh Province.

2.1. Data source

The primary data for this study were gathered from wheat growers during 2013–2014 cropping season. The data were collected from the wheat growers by the use of well-structured pretested set of questionnaires. In the questionnaire of wheat growers, information was collected of one ha as regards, labor costs, input costs, and returns of wheat production. Questionnaire was designed according to the objectives and hypothesis of research and questions were composed accordingly in order to collect valuable information.

2.2. Study area

This research work was conducted in three Copping Systems i.e. cotton-wheat, rice-wheat and Mixed cropping system and Six major wheat producing districts of Sindh Province in Pakistan which are mentioned below (see Fig. 1).

2.3. Sampling and data collection procedure

The disproportional simple random sampling was performed, which ensures that a sufficient number are selected from each group when groups are not equal in size (McMillan, 1990). For the analysis of the different zones of wheat economic efficiency, a case study has been mentioned followed. Sindh

Please cite this article in press as: Koondhar, M.A. et al., Comparing economic efficiency of wheat productivity in different cropping systems of Sindh Province, Pakistan. Journal of the Saudi Society of Agricultural Sciences (2016), http://dx.doi.org/10.1016/j.jssas.2016.09.006

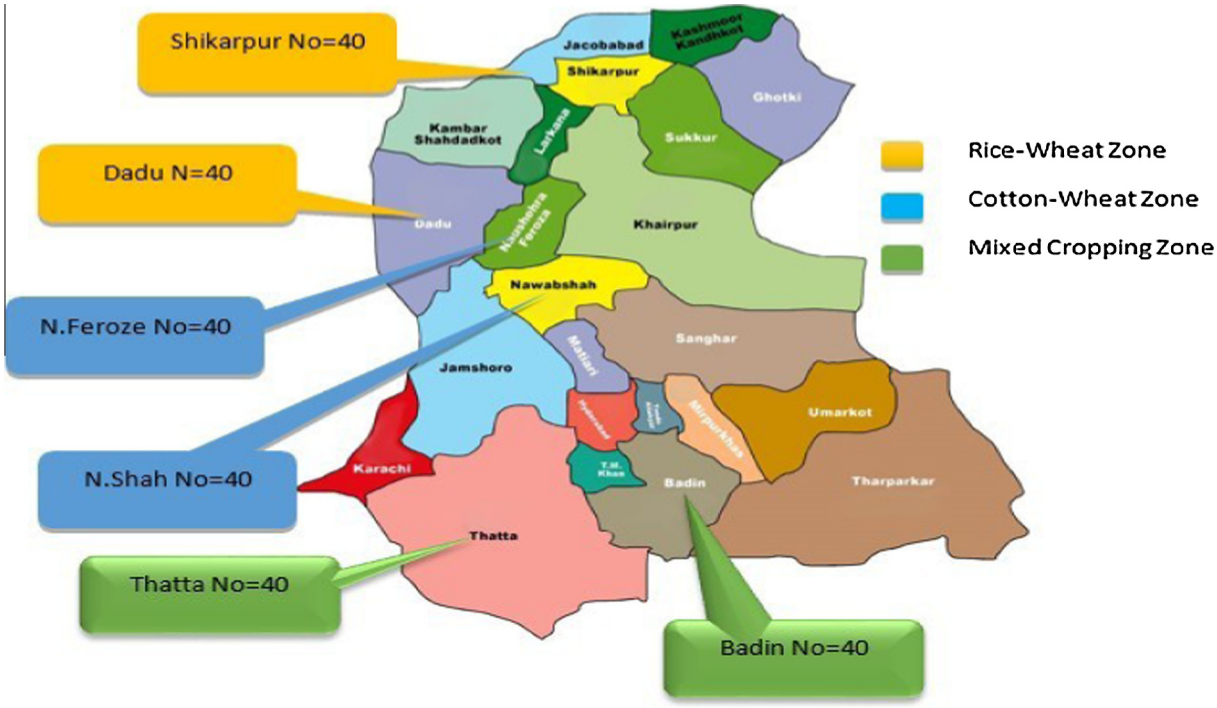

Figure 1 Study area by districts.

province was selected from Pakistan, Sindh province consists of different cropping zones, such as Cotton-wheat, Rice-wheat and Mixed cropping zone, from each zones two districts were selected and the case district was selected by the published seasonal (Rabi and Kharif) statistical report of the Pakistan. (Rabi crops cultivation started from October to November and harvested from March to May. Kharif crops cultivation started from 15th May to 15th July and harvested from September to October.) A total of 240 sample sizes were selected from all over the Sindh based on three major cropping systems, Cotton-what, Rice-Wheat and mixed cropping system, for each cropping system 80 farmers were selected, and two districts (40 samples) were selected from each cropping system. From each district two tehsils (20 samples) were selected and two villages were selected with 10 respondents through simple random sampling from each village. The sample size was determined by using the tables of ''Selecting the samples from a given population'' (Fitz-Gibbon and Morris, 1987; McCall, 1980; Wunsch, 1986) at 10% sampling error rate. From the wheat growers, 240 growers in total were determined as a sample size. The questioning with growers was carried out by face-to-face interviews, which allowed very detailed insights into the wheat production in Sindh province. The interviews of wheat growers were carried out from April, 2014 to June 2014. Each interview took around 25 min.

2.4. Data processing and analysis

A tabulation plan was developed for the presentation of summarized data. Preliminary data analysis such as frequency distribution, descriptive statistics and exploratory analysis was carried out to finalize the tabulation plan. Formal data analysis was conduct by SPSS software using Cobb-Douglas production function in logarithm form.

$$Y = \beta_0 X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} X_4^{\beta 4} X_5^{\beta 5} e^{\mu} \quad \text{(I)}$$

$$\text{Ln } Y = \ln \beta_0 + \beta 1 \text{Ln } X1 + \beta 2 \text{Ln } X2 + \beta 3 \text{Ln } X3 + \beta 4 \text{Ln } X4 + \beta 5 \text{Ln } X5 + \mu \quad \text{(II)}$$

where
Y = Yield of wheat in mounds per ha (dependent variable),
β_0 = Constant term (intercept),
β_i = Elasticity of production,
$X1$ = Ploughing (No/ha),
$X2$ = Seed rate (No/ha),
$X3$ = Irrigation (No/ha),
$X4$ = Fertilizer (Begs/ha),
$X5$ = Plant protection (No/ha),
μ = Error term.

$$Y = \beta_0 X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} X_4^{\beta 4} X_5^{\beta 5} e^{\mu} \quad \text{(III)}$$

$$\text{Ln } Y = \ln \beta_o + \beta 1 \text{Ln } X1 + \beta 2 \text{Ln } X2 + \beta 3 \text{Ln } X3 + \beta 4 \text{Ln } X4 + \beta 5 \text{Ln } X5 + \mu \quad \text{(IV)}$$

where
Y = Yield of wheat in mounds per ha (dependent variable),
β_0 = Constant term (intercept),
β_i = Elasticity of production,
$X1$ = Age,
$X2$ = Education,
$X3$ = Experience,
$X4$ = Family members,
$X5$ = Farm size,
μ = Error term.

3. Results and discussions

This section indicated the cost of production, physically productivity, and technically efficiency analysis. The cost of production includes variable cost and fixed cost, such as land preparation, seed price, fertilizer, farm yard manure, plant protection, irrigation cast, harvesting, land rent and land revenue. The physical productivity indicates, total cost of production net income and net return, and furthermore efficiency analysis to technically estimate which factors effect on wheat production in which cropping system. Cost of Production of Wheat crop/acre in Different cropping Zones: The input cost of average Yield per ha applied on wheat crop pertains to each cropping area which is accessible in Table 1. The average wheat yield per acre in Cotton-wheat, Rice-wheat, and mixed cropping zones was reported, 40, 38, and 39 mounds respectively and the average yield of the whole Sindh has reported 39 mounds per acre. Table 1 shows the direct positive relationship between wheat yield and farm size. The result is in line with that of Salam et al. (2002). Table 1 shows the average total cost of items according to farm size categories.

3.1. Variable cost

Variable costs are those costs which depend on a company production volume; they rise and decrease with the supply and demand of products. Variable costs are different compared to fixed costs.

3.2. Land preparation cost

Land preparation costs, were reported on Ploughing and Planking in the Cotton-wheat zone and farmers spend USD $28/ha and USD$27/ha, followed by the growers of the Mixed Cropping Zone and rice-wheat zone, spend the same amount of USD$25/ha on Ploughing and USD$24/ha on planking. The costs borne by all the Sindh cropping areas of Ploughing and Planking are USD$26/ha and USD$25/ha respectively.

3.3. Seed price

According to growers of the cotton-wheat zone, much money was also spend on Seed, which is USD$71/ha, again followed by the growers of mixed cropping and rice-wheat zone spend same and less amount of USD$70/ha and an average rate of seed price in overall Sindh growers spend USD$70/ha. In the case of planting cost the grower of rice-wheat zone spends more, USD$12/ha, followed by the growers of the cotton-wheat zone which is USD$9/ha and then the mixed cropping zone's farmers spend less amount of money which is USD$6/ha on wheat planting. The average cost for wheat planting in the overall Sindh is USD$9/ha.

3.4. Fertilizer

In the areas of Sindh province, most of the farmers applied Nitrogen fertilizer and this input is used in the terms of Bags,

Table 1 Per hectare cost of production (variable cost and fixed cost) of wheat crop in different cropping systems of Sindh. *Data source:* Author's calculated through use of SPSS 20.0.

Item	Unit	Cropping zones			Overall
		Cotton-wheat	Rice-wheat	Mixed cropping	
Variable cost					
Ploughing	$/ha	28	25	25	26
Planking	$/ha	27	24	24	25
Seed price	$/ha	71	70	70	70
Planting	$/ha	9	12	6	9
Urea	$/ha	42	48	48	46
DAP	$/ha	84	91	89	89
NP	$/ha	54	58	58	57
FYM	$/ha	29	35	35	33
Plant protection	$/ha	25	23	21	23
Tube well irrigation	$/ha	9	12	9	10
Harvesting	$/ha	53	51	51	51
Threshing	$/ha	87	84	84	85
Labor	$/ha	19	22	23	21
Total variable cost	$/ha	537	555	543	545
Fixed cost					
Land rent	$/ha	283	252	210	248
Land revenue	$/ha	9	8	9	9
Canal irrigation	$/ha	7	9	5	7
Total fixed cost	$/ha	299	269	224	264
Total variable cost	$/ha	537	555	543	545
Total cost of production	$/ha	836	824	767	809

Note: This table defines the cost of production of one hectare.

Please cite this article in press as: Koondhar, M.A. et al., Comparing economic efficiency of wheat productivity in different cropping systems of Sindh Province, Pakistan. Journal of the Saudi Society of Agricultural Sciences (2016), http://dx.doi.org/10.1016/j.jssas.2016.09.006

the growers of rice-wheat and mixed cropping zones spend much more amount on Urea which was measured USD$48/ha, cotton-wheat zone's grower spends little amount on urea which was measured USD$42/ha and an average rate of Sindh grower spends USD$46/ha, but in case of DAP fertilizer the grower of rice-wheat is higher, USD$91/ha, followed by the grower of mixed cropping zone spends USD$89/ha, and of cotton-wheat zone spends again less, USD$84/ha and overall Sindh growers spend USD$89/ha. Besides the NP fertilizer growers of rice-wheat zone and mixed cropping zone spend the same amount, USD$58/ha, followed by the grower of cotton-wheat zones spending less, USD$54/ha, and an average rate of overall Sindh growers spend USD$57/ha.

3.5. Farm yard manure

Farm yard manure is applied in wheat crop in Sindh province in terms of carts. According to the reporting of rice-wheat and mixed cropping zones, growers spend the same amount of farmyard manure, which is USD$35/ha. Compared with the two former zones, farmers of the cotton-wheat zone spend less, which is USD$29/ha. The average amount of Sindh province is USD$33/ha on farm yard manure.

3.6. Plant protection

It indicates that the growers of the cotton-wheat areas spend much more money, USD$25/ha for the use of plant protection on wheat crop compared with the mixed cropping zones, growers of which spend less amount, USD$21/ha, followed by the growers of the rice-wheat cropping zones spending USD$23/ha. The average amount spent by the growers of Sindh province is USD$23/ha.

3.7. Irrigation

In the study area, sample respondents used both canal and tubewell irrigation. In the case of rice-wheat zone's growers spend much more USD$12/ha followed by the grower of mixed cropping and cotton-wheat zone spend same and less amount of USD$9/ha on irrigation and in the case of overall Sindh growers spend USD$10/ha on irrigation.

3.8. Harvesting

According to the reporting of cotton-wheat growers, they spend USD$53/ha on the harvesting of a wheat crop but the mixed cropping and rice-wheat zone's growers spend the same amount of money which is USD$51/ha and the overall Sindh growers spend USD$51/ha on the harvesting of the wheat crop in Pakistan.

3.9. Threshing and labor

The cost of threshing reported by the growers of cotton-wheat zones is USD$87/ha, followed by the rice-wheat and mixed cropping zone's growers spend the same amount of money which is reported USD$84/ha on threshing and in case of labor cost including food grower of mixed cropping zones spend higher as compared to other zones, USD$23/ha, followed by the growers of rice-wheat zones spend USD$22/ha and cotton-wheat zone's grower spend USD$19/ha on labors. In the case of the overall amount of Sindh, growers spend on the wheat crop on threshing and labors, USD$85/ha and USD$21/ha.

3.10. Total variable cost

The total variable cost includes, ploughing, planking, seed price, planting, fertilizer, plant protection, irrigation, harvesting, threshing, and labor cost, which is reported higher in rice-wheat zone, USD$555/ha, followed by mixed cropping zone, USD$543/ha and in cotton-wheat zone, USD$537/ha. The overall Sindh province was reported USD$545/ha on wheat crop.

3.11. Fixed cost

In terms of management, fixed cost is those costs whose expenses don't change as activities function in business, within the relevant period. Consider fixed cost including land rent, and land revenue.

3.12. Land rent

An option within a lease contract grants the lease right to extend the period, and usually land rent is required to pay the premium such as an amount of money for every year of the original rent. According to the reporting of cotton-wheat zones growers paid USD$283/ha, as compared to the grower of mixed cropping zone's grower spend USD$210/ha and the growers of rice-wheat zones spend USD$252/ha. The overall Sindh province growers spend USD$248/ha for land rent in Pakistan.

3.13. Land revenue

Land revenue reported by the growers of the cotton-wheat and mixed cropping zones spend some amount, which is USD$9/ha, followed by the rice-wheat zones, USD$8/ha. Overall in Sindh province growers spend money on land revenue, USD $9/ha.

3.14. Total fixed cost

Total fixed cost paid by growers includes, land rent, land revenue and irrigation, which is reported higher amount of money spent by the grower of cotton-wheat zones, USD$299/ha, as compared to the grower of rice-wheat zone spends reasonable amount of USD$267/ha and the grower of mixed cropping zone's grower spends USD$234/ha. An average of overall Sindh growers spends USD$264/ha.

3.15. Physical productivity

Table 2 indicates, the results of yield, selling price and value of by-products of selected major cropping areas of Sindh province in Pakistan. Data indicate that growers of the cotton-wheat cropping zones received the yield of Wheat 99 mnds/ha, followed by the growers of the rice-wheat zones, receiving

Table 2 Per hectare gross income and Return from wheat crop in different cropping systems of Sindh. *Data source:* Author's calculated through use of SPSS 20.0.

Item	Unit	Cropping zones			Overall
		Cotton-wheat	Rice-wheat	Mixed cropping	
Yield	mnds/ha	99	94	96	96
Yield by-product	mnds/ha	99	94	96	96
Market value	rs/mnd	11	11	11	11
Market value of by-product	$/mnd	2	1	2	2
Income from grain	$/ha	1089	1034	1056	1060
Income from by product	$/ha	198	94	192	161
Gross income	$/ha	1287	1132	1248	1222
Total cost of production	$/ha	836	824	767	809
Net return	$/ha	451	308	481	413

Note: This table defines the gross income and net return of one hectare.

94 mnds/acre. Compared with the rice-wheat zone, the growers of the mixed cropping zones received more which is 96 mnds/ha, and the average wheat yield of Sindh province was reported 96 mnds/ha. In case of receiving amount of wheat grain all zone's growers received same amount USD$11/mnd because the government of Pakistan announced the subsidies rate for the growers but the market of by-product is different and it is worried upon distance of village and city; the grower of mixed cropping zone and cotton-wheat zones received same amount, USD$2/mnd, followed by the grower of rice-wheat zones received USD$1/mnd. The average rate received by overall Sindh growers was USD$2/ha as the value of by-product of the wheat crop.

3.16. Cost of production

Total cost is the sum of the fixed cost and variable cost for any given level of production, i.e., fixed cost plus the variable cost is equal to the cost of production. The growers of cotton-wheat zones spend USD$841/ha, which is more compared with the rice-wheat zones, and growers spend USD$827/ha, followed by the mixed cropping zone's growers, USD$780/ha, which is less compared to other zones. Overall, Sindh growers spend USD$816/ha as the cost of production on wheat crop in Pakistan.

3.17. Gross income

Gross income is acquired before any deduction by which sales revenue exceeds production cost. The gross income is shown in Table 2 including the market value of grains and by-product. As is shown in the table below, the cotton-wheat growers received USD$1287/ha from the wheat crop, followed by the growers of mixed cropping systems, getting USD$1248/ha but the growers of rice-wheat zones received less amount, which is USD$1132/ha due to a high cost of production but low yield. An average growers of the whole Sindh received USD$1222/ha.

3.18. Net return

Net return refers to the residual which remains for the entrepreneurs after subtracting production cost from the gross income. Net return is determined by per acre cost of average income, per acre realized by the growers. In the case of the net return, growers of the mixed cropping zones received USD$481/ha, more compared with the cotton-wheat zone's, growers received USD$451/ha. Followed by the growers of rice-wheat zones, they received less amount, USD$308/ha. The overall Sindh province growers received USD$413/ha net return from the wheat crop in Pakistan.

Furthermore the results of technical efficiency to measure through regression analysis are represented in Table 3 as the Cobb-Douglas production function was used so the estimated coefficient is the elasticity of the production. In case of cotton-wheat system, the intercept of −4.287 represents the natural log of the expected yield of wheat when there are no inputs. The coefficient of ploughing ($\ln X1$) is 0.263 and if the land preparation improves by 1% the yield of wheat will increase 0.263%. The coefficient of seed rate ($\mathrm{Ln}\, X2$) is 0.568 indicating that the yield will increase 0.568 by increasing the seed by 1%, ($\mathrm{Ln}\, X4$) is 0.155, which means if the application of plant protection improved by 1% the yield will increase 0.155%. There are only ploughing, seed and plant protection significant. Fertilizer and irrigation are non-significant in that most of the farmers in interior Sindh, are illiterate don't know about the recommendation doses of fertilizer and they also don't know what kind of soil they have and what fertilizer they apply; only they just follow the fellow farmers. Whatever's more, feudalism exists in the interior Sindh. Every landlord makes barriers in canals so that the small farmers can't use the irrigation properly and timely, which is the main reason the fertilizer and irrigation are non-significant in the cotton-wheat zone. The significant level is 0.5%, i.e. *R*-Square, the value of *R*-Square is 0.362, which indicates that it's about 36% of total change in the wheat yield, explained by these three independent variables. The value of *F*-calculated is 8.415 which is normally significant.

In comparison with cotton-wheat zone, mix cropping zone's results are displayed below in Table 3. The intercept of this model is 2.338 which represents the ordinary log of the estimated yield of wheat when there is no contribution of inputs. The coefficient of ploughing ($\mathrm{Ln}\, X1$) is 0.122 indicating that if the 1% improves the solicitations of land preparation according to results the yield will increase by 0.122% but the coefficient of seed rate ($\mathrm{Ln}\, X2$) is −0.376 results indicating that if 1% of seed is reduced then the yield will increase by 0.376%.

Please cite this article in press as: Koondhar, M.A. et al., Comparing economic efficiency of wheat productivity in different cropping systems of Sindh Province, Pakistan. Journal of the Saudi Society of Agricultural Sciences (2016), http://dx.doi.org/10.1016/j.jssas.2016.09.006

Table 3 Summery statistics of wheat production in different cropping systems of Sindh Province.

Variables	Cotton-wheat			Rice-wheat			Mixed cropping			Overall Sindh		
	Coefficient	T-state	Sign level	Coefficient	T-state	Sign level	Coefficient	T-state	Sign level	Coefficient	T-state	Sign level
Intercept	−4.287	−3.359	0.001***	4.088	5.305	0.000***	2.338	3.535	0.001***	1.402	3.550	0.000***
Ploughing (X_1)	0.263	3.227	0.002***	0.137	2.886	0.005***	0.112	1.919	0.059*	0.185	5.258	0.000***
Seed (X_2)	0.568	2.867	0.005***	−0.700	−4.901	0.000***	−0.376	−3.195	0.002***	−0.218	−2.861	0.005***
Fertilizer (X_3)	0.581	0.254	0.630	−0.157	−2.387	0.020**	0.130	2.804	0.006***	0.096	4.152	0.000***
Plant protection (X_4)	0.155	2.416	0.051***	0.098	2.198	0.031**	0.017	0.484	0.630	0.053	2.154	0.032**
Irrigation (X_5)	0.084	1.446	0.152	−0.053	−1.053	0.296	−0.097	−1.983	0.051**	−0.053	−1.690	0.092*
State	R^2, 0.362	F, 9.876	D.W, 1.9	R^2, 0.400	F, 9.876	D.W, 1.1	R^2, 0.400	F, 9.876	D.W, 1.4	R^2, 0.260	F, 16.404	D.W, 1.6

Note: From each system selected 80 farmers data were analyzed through SPSS 20.0.
*** Significant level at 1%.
** Significant level at 5%.
* Identifies the significant level at 10%.

The coefficient of fertilizer (Ln $X3$) is 0.130, the results of which indicate that 0.130% wheat yield will increase when the application of fertilizer increased by 1% but the coefficient of irrigation (Ln $X5$) is −0.097, which represents that when we reduce 1% of irrigation then our yield will increase 0.097%. In the mixed cropping zone, ploughing, seed, fertilizer, and irrigation are significant but the plant protection is non-significant because the illiteracy ratio is higher in the mixed cropping zone, so people don't know very well about the quantity and quality of the plant protection, and what and how much to use, i.e. R-Square, the value of R-Square is 0.400, indicating that some 40% of total change in the wheat yield is explained by these four independent variables which are represented in Table 3b. The value of F-calculated is 9.876, which means it is also normally significant in mixed cropping zone.

Compared with the two cropping systems above, the rice-wheat zone's results are a little bit different which are also available in Table 3. The intercept of the rice-wheat zone is 4.088, which denotes the ordinary log of the assessed yield of wheat when there is no involvement of inputs. The coefficient of ploughing (Ln $X1$) is 0.137, which signposts that if we improve 1% ploughing then the yield of wheat will increase by 0.137%. However, the coefficient of seed rate (Ln $X2$) is −0.700, which represents that we can get 0.700% increase in the yield of wheat when 1% of seed is reduced. The coefficient of fertilizer (Ln $X3$) is also negative, −0.157, represented in the Table 3c, showing that if we reduce 1% of fertilizer, then we can increase our yield by 0.70%. The coefficient of plant protection (Ln $X4$) is 0.098, representing that we can gain 0.098% of wheat yield when we increase 1% of application in plant protection. The significant level is less than 5%. In the rice-wheat zone, ploughing, seed, fertilizer, and plant protection are significant but the irrigation is non-significant in that the rice-wheat zone is in shortage of water in Rabi season and the rice canal is only opened in Kharif season So the irrigation in negative, i.e. R-Square, the value of R-Square is 0.406, meaning that some 40.6% of total change in wheat yield is explained by these five independent variables which are represented in Table 3c. The value of F calculated is 10.118, which means it's highly significant compared with mixed cropping and cotton-wheat zones.

The data results of the overall cropping systems of Sindh province are represented in Table 3. The intercept of overall Sindh is 1.402, which signifies the ordinary log of the estimated yield of wheat when there is no use of inputs. The coefficient of ploughing (Ln $X1$) in Sindh province is 0.185 denoting that if we improve 1% of land preparation application, then we can improve yield by 0.185%. However, the coefficient of Seed rate (Ln $X2$) is -0.218, indicating that we can increase 0.218% yield of wheat when we reduce 1% of seed application. The coefficient of fertilizer (Ln $X3$) is 0.096 identifying that if we increase 1% of fertilizer, then we can increase our production by 0.096%. The coefficient of plant protection (Ln $X4$) is 0.053 representing that if we increase 1% of application in plant protection, then we can increase 0.053% of yield wheat. And the coefficient of Fertilizer is −0.053 indicating that if we reduce 1% of application in irrigation, then we can increase 0.053% of wheat yield. In the whole Sindh province, all the factors are significant, and the significant levels of ploughing, seed, fertilizer and plant protection are all under 5%, and only irrigation is under 10%, i.e. the R-Square, the value of R-Square is 0.260 meaning that some 26% of the total wheat change in the

Sindh province is explained by these five independent variables which are represented in Table 3d. The value of *F*-calculated is 16.404 showing that it's the high significant level. This suggests that the independent variables included in the model significantly affect the wheat yield. These results are in line with the earlier studies which were conducted by Hussain et al. (2005), Buriro et al. (2013), Kazgan (1983), and Semerci et al. (2012).

In addition the results of socioeconomic conditions impact on wheat production in different cropping systems of Pakistan are present in Table 4 and the results of yield in cotton-wheat cropping system indicate 0.577 coefficient without using any input, age and family members have significant relationship with production, farm size, experience and education doesn't have impact on production, and the coefficient of age is negative and significant at 5% level related to wheat production, which implies the probability of production decreases with old farmers. It can be predicted such farmers are very old, and they do not have own machinery and they are using traditional method for cultivation that can effect on yield. Moreover the coefficient of production is positive with 10% significant level, and family members have impact on production, which indicates the family members have probably increased the production with family size, may be due to big family increases the family labors in farm, so that it impacts on production, and the value of R2 is 13 which is normally significant, but the value of D.W is 1.6, which implies the serial correlation between, family members, age, and Yield. As compared to cotton-wheat cropping system, all variables of rice-wheat systems are significant except farm size, and the coefficient of age is 0.297 which is significant at 5% level, which implies if the aged/old peoples work in the field the production will be increased at 0.297% per ha. The coefficient of education is 0.350 with 10% significant level which implies that the 1% education can increase 0.350% of wheat production, Moreover 0.241 is the coefficient value of experience which is significant at level 10%, and this implies the production of 0.241% can be increased with the increase of 1% farming experience, and the coefficient of family size is 0.510 at 10% significant, which indicate if 1% family workers/members increase the production will increase by 0.510%. Farm size doesn't have a significant correlation with production, and maybe farmers look after the crop equally.

What's more, as compared to cotton-wheat, and rice-wheat in mixed cropping system, age and farm size do not have significant impact on production but the education, experience, and family members have significant correlation with production, and the education is significant with 1% with the coefficient of 0.991, which indicate if the education increases by 1% then the production can increase by 0.991%. In addition, the coefficient of experience is 0.322 with 10% significant level, that implies 0.322% production can increase owing to 1% increasing experience. The coefficient value of family members is −0.724 with significant at level 10% which implies the production can increase at level 0.724% owing to decrease of 1% family members, mixed cropping zone is coastal area that is the most illiterate area of Sindh province, and so farmers don't send their children for education, children also work in the field, children do not have any experience of farming and so just waste/destroy the field area, that's way the family members in mixed cropping area have negative impact. So the value of R2 is 25 showing the normal significant relation between,

Table 4 Socioeconomic variables effect on wheat production in different cropping systems of Sindh.

Variables	Cotton-wheat			Rice-wheat			Mixed cropping			Overall Sindh		
	Coefficient	T-state	Sign level	Coefficient	T-state	Sign level	Coefficient	T-state	Sign level	Coefficient	T-state	Sign level
Intercept	42.322	7.863	0.000***	39.494	7.197	0.000***	34.511	5.348	0.000***	38.050	12.415	0.000***
Age (X_1)	−0.335	−2.477	0.016**	0.298	2.378	0.020**	0.161	1.581	0.117	0.133	1.909	0.057*
Education (X_2)	0.289	1.438	0.155	0.351	1.873	0.065*	0.992	4.162	0.000***	0.418	3.421	0.000***
Experience (X_3)	0.263	0.757	0.583	0.250	1.744	0.085*	0.322	1.922	0.057*	0.065	0.768	0.443
Family members (X_4)	0.491	1.712	0.091*	0.511	1.928	0.057*	−0.725	−1.721	0.088*	0.004	0.924	0.356
Farm size (X_5)	0.004	0.628	0.532	0.003	0.459	0.647	0.026	0.679	0.498	−0.217	−2.873	0.004***
State	R^2, 13	*F*, 2.339	D.W, 1.6	R^2, 15	*F*, 2.599	D.W, 1.3	R^2, 25	*F*, 5.712	D.W, 1.3	R^2, 10	*F*, 5.422	D.W, 1.3

Note: From each system selected 80 farmers data were analyzed through Eviews 8.0.
*** Significant level at 1%.
** Significant level at 5%.
* Identifies the significant level at 10%.

production, family members, education and experience, and the value of D.W is 1.3 which shows serial correlation. What's more, in overall Sindh the coefficient of wheat production is 38.050 when no one input was used, after the input using just age, education and farm size having significant relation with production, and other (experience and family members) doesn't have an impact on production. The coefficient of age is 0.133 with 10% significant level which indicates that 0.133% production can increase owing to increasing 1%. In addition the coefficient of education is 0.418 which is significant at 1% level that indicates if education increases 1% production will increase by 0.418%, and in final the coefficient of farm size is −0.217 negatives, with 1% level of significant, which shows if we reduce 1% farm size wheat production can increase at 0.217% level. Farm size has negative impact on most of the farmers and landlords can't afford so many inputs on time they need to credit from adage (Local trader/Bari) which markups 20–30% which is high so most of the farmers use low applications of inputs which effect on the field.

4. Conclusion

This paper has examined the wheat productivity in different cropping systems such as Cotton-wheat, Rice-Wheat and mixed cropping systems of Sindh. Results indicate that in the case of mixed cropping zone, wheat yield increases as ploughing, seed and plant protection. The dominant factors behind yield increase in the cotton-wheat cropping zone are ploughing, seed, fertilizer, and irrigation. Wheat yield of the Rice-wheat system will increase linearly as ploughing, seed, and fertilizer as well as plant protection measures. On the overall basis, data collected across Sindh Province indicate that wheat yield increases as a result of the increase in the major independent variables. Salinity and water logging are the driving threats leading to high water table in most regions of upper Sindh. Due to poor land management and improper irrigation strategies, the coefficient of irrigation shows a negative value. Contrarily, in lower Sindh, canal irrigation water is needed (i.e. Mixed and cotton-wheat zone), but most of the areas have unfit ground water for irrigation, thus increasing the soil erosion and salinity. It means that the accumulative salinity in the overall Sindh is the major factor to reduce the size and number of the grains per spike. In the cotton-wheat and Mixed cropping zones, farmers cultivate sugarcane, affecting the sowing date of wheat due to much time is taken by the standing crop. Therefore, most of the farmers cultivate wheat at the end of December when the crop reaches milky stage where the temperature will increase, having effects on the grain size, weight, and the number of grains per spike.

Furthermore, the results of the socioeconomic condition include age, education, experience, family members and farm size. In case of cotton-wheat zone age is significant at 5% level but with negative coefficient, which implies the production can increase owing to decrease in age, especially in Cotton-wheat cropping system of Sindh province and every old farmer want to educate his children, so when his children become young they sent their children to cities for higher education. They don't want to work in the field, farmers doesn't have energy, due to oldness, as they can't look after very carefully the field that's why age has negative effect on yield. As compared to cotton-wheat in rice-wheat almost all variables are significant except farm size, in this system and all variables are positively significant at 10%, 5% and 1%, which indicate that production can increase with increase in age, education, experience, and family members. Rice-wheat is upper part of Sindh province, in this part feudalism is very serious problem for poor farmers, and all family members work in the field, including children, who do not have any field experience; due to feudalism they shouldn't send their children for education, that's why they have serial correlation with production. As compared to rice-wheat and cotton-wheat, in the mixed cropping system, education, experience, and family member are significant at 1%, 5%, and 10%, except age and farm size, which are non-significant, which implies that production can increase with the increase in education and experience but the family members have negative impact that implies production can increase with decrease in family members; mixed cropping zone is lower part of Sindh which is coastal area, in this part 90% peoples are illiterate, they do not want to educate their children, and whole family work in the field, including children with less experience, that's why they have serial correlation with production. When we are looking the situation of overall Sindh age and education have positive impact on yield with 1% significant level, which implies that wheat production of overall Sindh can increase with increase in age and education, but the farm size is also significant at level 5% with negative coefficient that implies production will increase with reduction in farm size; overall Sindh feudalism is dominant on small farmers, and landlords, do want to educate children of farmers, because children also work in field. In Sindh have a trade small scale farmers, and landlords, get inputs as credit from adage, (local trader/Bepari) that markup is very high 20–30, so farmers try to use fewer inputs because they can't afford for large farm size, that's why they have negative effect on yield. In addition, the cost of production estimates that in the case of cotton-wheat zone, growers spend as much as USD$841/ha. In comparison, rice-wheat zone's growers spend USD$827/ha, followed by the growers of the mixed cropping zones, spending USD$780/ha. The overall Sindh growers spend USD$816/ha. In the case of cotton-wheat zone, growers received gross income from wheat crop at USD$1287/ha, followed by the growers of the mixed cropping zone, receiving USD$1132/ha, but the growers of the rice-wheat zone have received less, USD$1248/ha because of the high cost of production but low yield. The overall Sindh growers received USD$1222/ha. In the case of the mixed cropping zone, growers received a high net return of USD$481/ha. In contrast, the cotton-wheat zone's growers received USD$451/ha, followed by the growers of the rice-wheat zone receiving USD$308/ha. The growers in the overall Sindh province received USD $413/ha of net return from the wheat crop in Pakistan. In fact, there is feudalism in Sindh province, the landlords own tractors and implements so that they cultivate crop on the recommended time and apply recommended doses of fertilizers, irrigations, and plant protection applications. On the other hand small farmers remain under pressure of landlord because they doesn't have own agricultural capitals. Therefore, small farmers take credit from landlords in various kinds such as seeds, fertilizers, and pesticides at a high-interest rate. Nevertheless, farmers should be aware of profitability and cost of production in different cropping zones and adapt their production to obtain the highest possible net profit (Engindeniz, 2007).

Please cite this article in press as: Koondhar, M.A. et al., Comparing economic efficiency of wheat productivity in different cropping systems of Sindh Province, Pakistan. Journal of the Saudi Society of Agricultural Sciences (2016), http://dx.doi.org/10.1016/j.jssas.2016.09.006

According to Chandio et al. (2015), it was reported that formal institutions should supply agricultural credit on flexible terms and conditions that are the quickest way to increase agricultural productivity and improve the well-being of small farmers. Koondhar et al. (2015) also, suggest that Sindh Seed Corporation should produce seeds which are suitable to cultivate in saline soil and the heat tolerant wheat. At the same time, the growers should cultivate with certified seeds which are produced by Sindh Seed Corporation and Wheat Research Institute Sakrand. Generally, farmers in Sindh always produce their seed according to Sindh temperature, and not try to cultivate with seeds from other provinces. However, temperature varies from province to province, and if seed types in other provinces can fit in Sindh's environment well, local farmers will get good results; otherwise, farmers receive low productivity at 20–25 mnd/acre. Therefore, Sindh Seed Corporation and other seed corporations should develop more favorable seed types, and the government should take more beneficial measures to guarantee the benefits of the farmers; meanwhile, a coworker with the seed corporations promotes the use of good seed types.

Author's contributions

All authors contributed to the present research. **Mansoor A. Koondhar:** performed this research, and wrote and revised the paper, and this research was financially supported by **Ge He** and **Lingling Qiu** contributed to data entry and analysis. **Habibullah Magsi.** Help to Make the survey plan, checking Plagiarism and all around encouragement in research activities and processing the data for analyzing. **Abbas A Chandio** contributed in field survey, all authors read and approved this manuscript for publishing.

References

Buriro, R.A., Kharoo, A.A., Talpur, G.H., Rajput, M.I., 2013. Technical efficiency of wheat farming in Sindh province of Pakistan. Pak. J. Agric., Agric. Eng. Vet. Sci. 29 (1), 77–87.

Byerlee, D., Siddiq, A., 1994. Has the green revolution been sustained? The quantitative impact of the seed-fertilizer revolution in Pakistan revisited. World Dev. 22 (9), 1345–1361.

Chandio, A.A., Yuansheng, J., Koondhar, M.A., 2015. Raising maize productivity through agricultural credit a: case study of commercial banks in Pakistan. vol. 7, no. 32. ISSN 2222-1905 (paper) ISSN 2222–2839 (online).

Cinteol and Azetec Maize Diety, 2015. World wheat production, maize production and rice production. <www.nue.okstate.edu/Crop.../World_Wheat_Production.htm>.

Engindeniz, S., 2007. Economic analysis of processing tomato growing: the case study of Torbali, west Turkey. Span. J. Agric. Res. 7 (5), 7–15.

Fitz-Gibbon, C.T., Morris, L.L., 1987. How to Design a Program Evaluation. Sage Publications, Beverly Hills.

Gall, M.D., Borg, W.R., Gall, J.P., 1996. Educational Research: A Critical Appraisal. Michigan State University, East Lansing.

GoP, 2003. Economic Survey of Pakistan 2003. Agricultural Statistics of Pakistan. Ministry of Food Agriculture and Livestock Division, Islamabad.

GoP, 2015. Economic Survey of Pakistan 2014–15. Agricultural Statistics of Pakistan. Ministry of Food Agriculture and Livestock Division, Islamabad.

Hussain, S., Tabasam, N., Iqbal, J., 2005. An economic analysis of wheat farming in the mixed farming zone of Punjab Province, Pakistan. J. Agric. Soc. Sci. 1813–2235/2005/01–2–167–171.

Kazgan, G., 1983. TarimveGelisme. Der Yayinlari, Istanbul (Turkish).

Koondhar, M.A., Chandio, A.A., He, G., Joyo, M.A., Koondhar, M. A., Jamali, R.H., 2016. An Effect of support price toward the growth rate of Sugarcane production: evidence from Sindh and Punjab provinces of Pakistan. Int. J. Agric. Mark. 3 (1), 097101.

Koondhar, M.A., Chandio, A.A., He, G., Xaio, X., Koondhar, M., 2015. Economic analysis of hybrid maize cultivation in distt Naushahroferoze, Sindh, Pakistan. J. Poverty Dev. Invest. 18.

McCall, C., 1980. Sampling and Statistical Handbook for Research in Education. National Education Association, USA.

McMillan, J.H., 1990. Educational Research: Fundamental for the Consumer. Harper Collins College Publisher, USA.

PARC (Pakistan Agricultural Research Council), 1996. National Master Agricultural Research Plan (1996–2005). Ministry of Food, Agriculture and Livestock, Islamabad.

Rajarams, Hobbs, P.R., Heisey, P.W., 1998. Review of Pakistan's wheat and maize research systems. Report Submitted to PARC by a Multidisciplinary Team of CIMMYT Scientists visited Pakistan.

Salam, A., Siddique, M.B., Zaidi, S.W.R., 2002. Economics of Wheat Production: Results from Field Surveys in Punjab and Sindh. Agricultural Prices Commission, Govt. of Pakistan, Islamabad. Apcom Serial No. 202.

Semerci, A. et al, 2012. The production functions of wheat production in Turkey. J. Bulg. J. Agric. Sci. 18 (2), 240–2537.

Usman, M., 2016. Contribution of agriculture sector in the GDP growth rate of Pakistan. J. Glob. Econ. 4, 184. http://dx.doi.org/10.4172/2375-4389.1000184.

Wunsch, D.R., 1986. Forum feature: action research in business education. Bus. Educ. Forum 5, 31–34.

Please cite this article in press as: Koondhar, M.A. et al., Comparing economic efficiency of wheat productivity in different cropping systems of Sindh Province, Pakistan. Journal of the Saudi Society of Agricultural Sciences (2016), http://dx.doi.org/10.1016/j.jssas.2016.09.006